NBSIR 85-3223

Data Sources for Parameters Used in Predictive Modeling of Fire Growth and Smoke Spread

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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Abstract

Sources of data needed for predictive modeling of fire growth by FAST and ASET, two computer codes developed at the Center for Fire Research, are identified for a few selected materials. Data includes thermophysical properties of compartment lining materials and burning rates and combustion product generation rates for typical combustible contents.

Keywords: ASET: Burning rate; Combustion products; FAST: Fire models; Fire properties; Heat release; Smoke generation; Thermal inertia; Thermal properties

Data Sources for Parameters Used in Predictive Modeling of Fire Growth and Smoke Spread

D. Gross

Introduction

There is a need to assemble, in convenient form, available data on materials and products which could serve as input for predictive models of fire growth, smoke transport, and ultimately, "smoke hazard development." These data, which are often referred to as "properties" or "fire properties," generally refer to two principal groups of products: (a) burning items, i.e. furnishings and contents, constituting the combustible "fuel" in an assumed fire scenario, and (b) materials and products comprising the enclosing compartment surfaces. In addition to such material-related data, models also require specified values of coefficients which describe the heat and mass flow processes; these are not associated with specific materials or products. In the more detailed deterministic models there are likely to be progressive ignitions of the combustible contents and the materials comprising the enclosing surfaces, so it is critical to know and understand what constitutes the likely "reactions to fire" or "responses to temperature, heat and flame" of these products. These are more precise terms than "fire properties," since in most cases, these responses are not essential ("intensive") attributes or properties in the traditional sense; instead, they depend strongly on mass or volume ("extensive attributes") as well as on physical form, environment, exposure, etc.

Conventional thermophysical and thermochemical property data are available in reference sources; they are generally listed for pure or well-characterized materials under steady-state or quasi-steady-state conditions. Measurements are unusually based on idealization of ambient atmosphere and thermal

exposure, usually constant temperature. Properties of inorganic materials are generally available up to elevated temperatures. Organic materials, with or without flame retardant chemicals, experience significant endothermic and exothermic reactions, phase changes, and physical changes (e.g. deformation, cracking, charring) which sometimes limit measurement of thermophysical properties beyond ordinary or moderately elevated temperatures.

Predictive models of fire growth require values for specified input "parameters" in specified formats. These differ among models as shown in Table 1 for three common models used by the Center for Fire Research (CFR) staff [1,2,3]. A somewhat different set of parameters results when individual modelers and users list those parameters which they consider necessary to provide solutions to the energy, mass and species conservation equations governing fire and smoke spread. In many cases, researchers are strongly tied into specific measurements of ignitability, flame spread, heat release and smoke generation using specific test equipment and exposure conditions. Many of these input data are not thermophysical or thermochemical properties, but are process-dependent variables which should logically be computed rather than assumed as input. This distinction between properties (essential attributes) and fire test responses is carried through in the compilations which are to follow.

This brief initial compilation is intended to provide users of the simpler models, FAST and ASET, with information required for computations for a few selected materials. This involves (a) thermophysical properties of the compartment lining materials, and (b) burning rates (mass loss rates) and product generation rates for typical combustible contents.

Thermophysical Properties

Where the thermophysical properties of compartment lining materials are taken into account, it is usually important to know how thermal conductivity (k) and specific heat (c) vary with temperature. Density (ρ) may also vary with temperature but this is usually to a lesser degree, and such data are

usually not measured or compiled. In some cases, thermal conductivity and specific heat may vary by factors of up to five over the temperature range of interest. Where phase changes or chemical reactions occur, the apparent specific heat may undergo a sudden large change. If the actual kinetics of these reactions are not taken into account, an effective value of the specific heat may be used over the appropriate temperature range. Since measurement techniques differ, and since k and c are difficult to measure at elevated temperature, the user should consult the original sources for stated (or unstated) precision estimates and limitations. Total normal emissivity (ε_N) is important, but at the ordinary temperatures where measured values are generally available, and for typical compartment lining materials, the variation is not great.

Table 2 provides tabular and graphical values of thermal conductivity and specific heat for the following materials:

Inorganic	Organic
Clay brick (common)	Wood (pine, spruce, hemlock, redwood)
Concrete, normal weight	Wood (Douglas fir, sugar maple)
Gypsum board, standard	Wood (oak, birch, silver maple)
Gypsum board, Type X	PMMA
Calcium silicate board	PVC
Ceramic fiber	Polystyrene
Mineral fiber	Polystyrene Foam
Steel	

The product $k\rho c$, sometimes called "thermal inertia", is also listed for information. The room temperature values of k and c for several other materials are given in Table 3. Table 4 lists selected values of total normal emissivity; more complete listings are available in standard reference sources, e.g. [4].

Fire Responses of Combustible Contents

FAST and ASET require as input the burning rate (mass loss rate) and rate of heat release, respectively, of one or more combustible contents. This is not necessarily assumed to be constant so that a graph of burning (or heat release) rate versus time is required. The production rate of gaseous species (e.g. CO, CO_2, HCN, etc.) and of smoke (particulates) also needs to be specified for FAST. Since additional information on the burning process is also necessary, numerical values cannot be simply tabulated. In this case, sources of data on the burning characteristics of furnishings and contents have been assembled in Table 5 together with a classification as to the type (peak or total) and form (tabular or graphical) in which the data are presented. Some data apply to burning in the open and others to burning inside a compartment where the air may become vitiated in the advanced burning stage. In some cases, heat release rates for objects burning within a compartment may be greater than those in the open due to radiant feedback from heated surfaces. The user should consult those references which provide data in the form desired. The types of products or materials include: chairs, sofas, mattresses, beds, wastebaskets, cross-piles of wood and plastic, bookcases, closets, office furniture, etc. For convenience, Table 6 provides some graphical and tabular values for common furnishings, such as upholstered and plain chairs, sofas, mattresses, closet wardrobes, curtains, televisions, and wastepaper baskets.

Rate of heat release is the basic driving force in fire growth so that its measurement and characterization is the most critical input for modeling. Where the heat release rate of the initial burning item has been measured directly, e.g. by a full-scale or bench-scale calorimeter, it can be used directly as input data. Where only the mass loss rate has been measured (or can be estimated), the rate of heat release may be calculated using an appropriate value of heat of combustion. This may be the net heat of combustion from oxygen bomb calorimetry (assuming complete combustion) or an effective net heat of combustion (assuming partial combustion). Where a more exact estimate is called for, the net heat of combustion may be adjusted to take into account the extent to which incomplete combustion results in the formation of char, soot and carbon monoxide. In this case,

it is necessary to have additional information, including chemical composition and heats of formation, vaporization, and gasification. Some of this information has been assembled for selected generic combustible materials in Table 7. Other values must be assumed or obtained from reference sources.

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Table 1. Input Parameters Specified in Selected Fire Growth Models

Compartment Materials	FAST	ASET	Harvard V (H 05.2)
Density	X		X
Thermal Condustivity	X		X
Specific Heat	X		X
Emissivity	X		X
Combustible Contents			
Burning (mass loss) rate	X		
Heat release rate		X	
Area of fire	X		
Fire growth rate		X	X
Production rate of species[a]	X	X	X
Density			X
Thermal Conductivity			X
Specific Heat			X
Emissivity			X
Heat of Combustion	X	X	X
Heat release fraction	X		X
Heat of reaction (pyrolysis			X
Ignition temperature			X
Pyrolysis temperature			X
Air/fuel mass ratio			X
Fire spread parameter			X
Heat and Mass Flow Processes			
Fractional radiation heat loss rate		X	
Fractional conductive heat loss rate		X	
Heat transfer coefficient			X
Flow (discharge) coefficient			X
Plume entrainment coefficient			X
Flame extinction coefficient			X

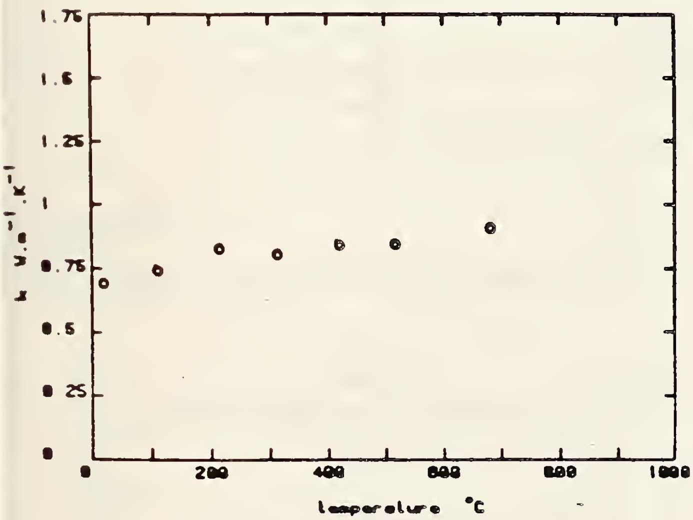
[a]Species: N_2; 0_2; CO_2; HCN: HCℓ; THC; $H_2 0$; smoke; $\%LC_{50}$; smoke ND; HCℓ ND

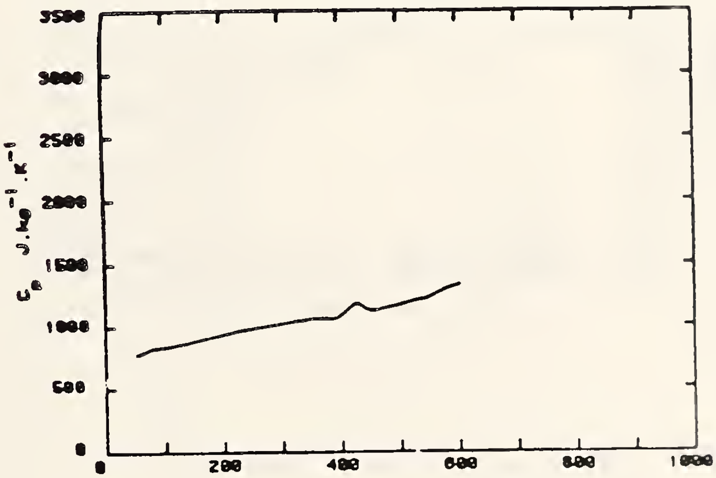
Table 2. Thermal Conductivity, Specific Heat and Thermal Inertia of Selected Inorganic and Organic Materials

Material: Clay Brick (Common)

Density: 1900 kg/m^3 (120 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.72	750	1030 x 10^3
100	0.75	800	1140
200	0.8	900	1370
500	0.85	1200	1940
800	0.9	~ 1500	~ 2560



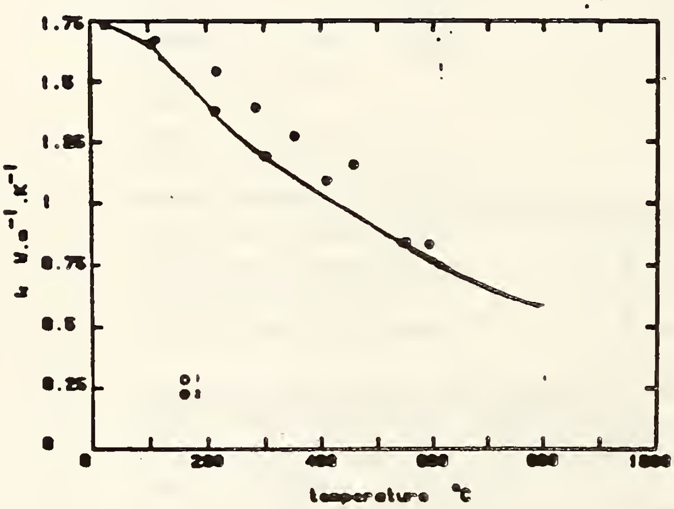


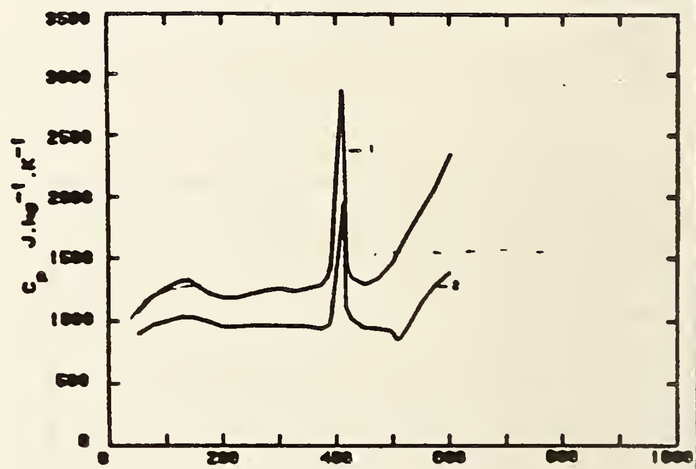
Ref. 17

Material: Concrete, normal weight

Density: 2200 kg/m^3 (140 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\,m^4 K^2}$
20	1.75	1000	3850 x 10^3
100	1.70	1200	4490
200	1.38	1200	3640
500	0.90	1500	2970
800	~ 0.6	~ 1500	~ 1980





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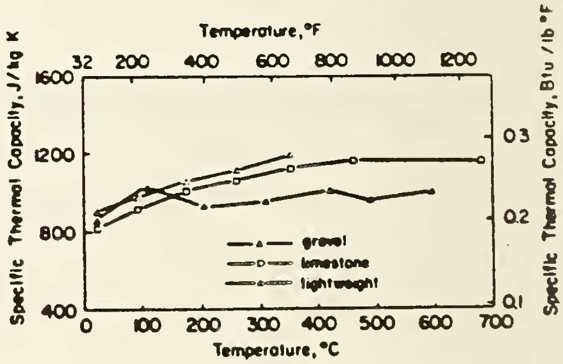


FIG. 23—*Specific thermal capacity for different types of concrete* [49].

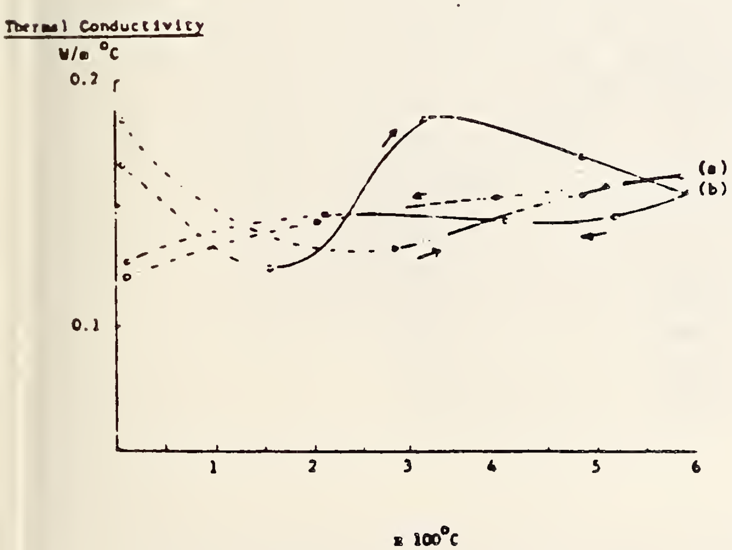
Material: Gypsum Board   A. Standard
B. Type X

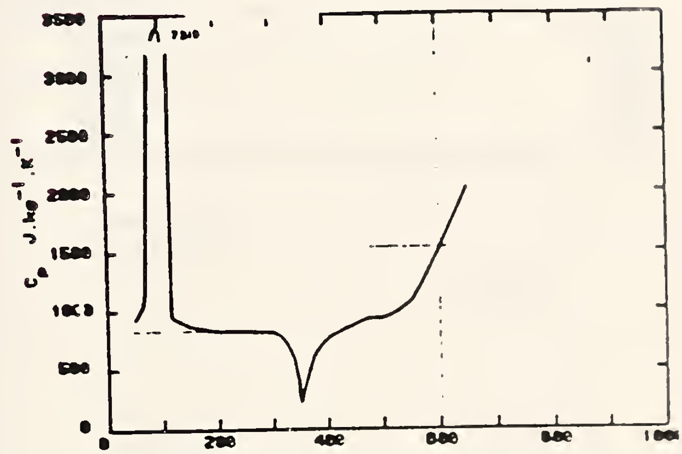
Density: (A): 790 kg/m^3 (49 pcf)
(B): 770 kg/m^3 (48 pcf) } pcf ≡ pounds/cubic foot.

Temp. °C	A. Standard: Thermal Conductivity k W/m K	A. Standard: Specific Heat c J/kg K	A. Standard: kρc $\frac{J^2}{sm^4K^2}$	B. Type X: k	B. Type X: c	B. Type X: kρc
20	0.18	900	128 x 10^3	0.16	900	111 x 10^3
100	0.15	900	107	0.13	900	90
200	0.13	800	82	0.13	800	80
500	0.15	900	107	0.17	900	118

Remarks : (a) Plasterboard (790 kg/m^3).
(b) Plasterboard incorporating less than 5% glass fibre (770 kg/m^3).

Reference : Report 7040 384C Statens Provingsanstalt, Stockholm (1980).





$\alpha(20°C) \cong \frac{0.16}{790(900)} = 2.25 \times 10^{-7}$

or $\frac{0.18}{770(900)} = 2.60 \times 10^{-7}$

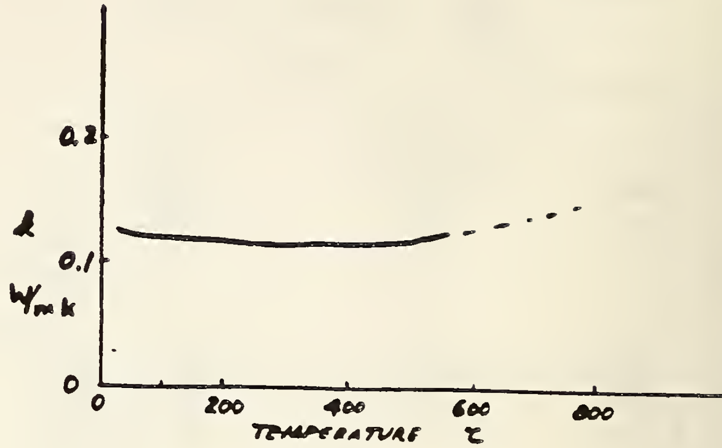
Ref. 17,19

Material: Calcium Silicate Board (Marinite I)

Density: 740 kg/m^3 (46 pcf)

Thermal Conductivity (Btu-in. sq. ft.·°F/hr.)

Temperature °F	k
75	0.88
350	0.82
400	0.81
500	0.80
600	0.79
700	0.80
800	0.81
900	0.83
1000	0.86



Specific Heat

Temperature °F	Specific Heat Btu/°F/lb.
200	0.28
400	0.30
600	0.32
800	0.34

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\,m^4K^2}$
20	0.13	1120	108 x 10^3
100	0.12	1170	104
200	0.12	1260	112
500	0.12	1430	127
800	~0.15	~1600	~178

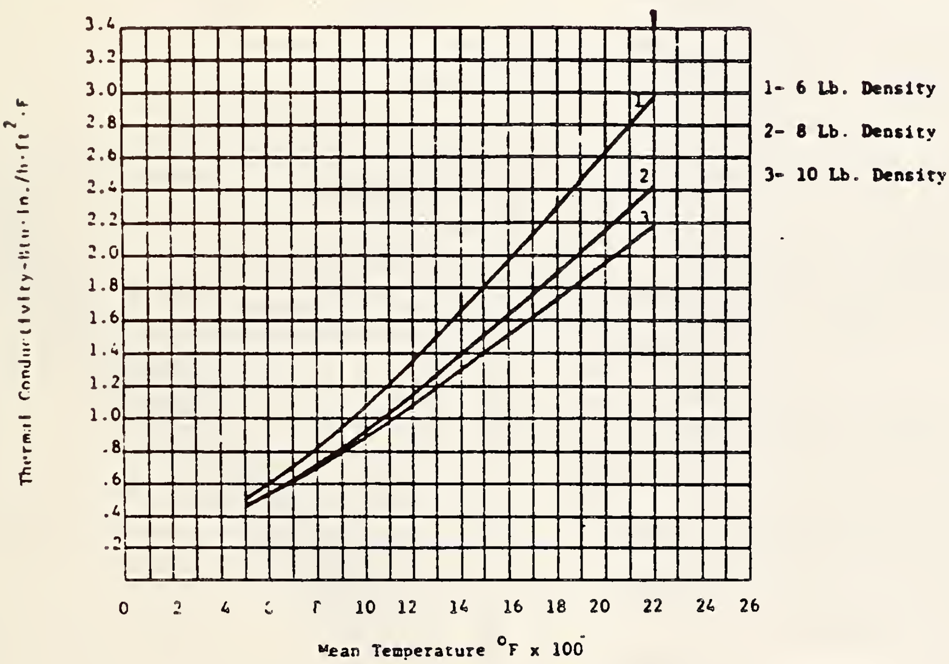
Ref. 20

Material: Ceramic Fiber (Kaowool 2600 Modules)

Density: 130 kg/m^3 (8 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.030	1050	4.1×10^3
100	0.040	1050	5.5
200	0.065	1060	9.0
500	0.12	1070	16.7
800	0.21	1080	29.5

*Thermal Conductivity - Kaowool 2600 Modules



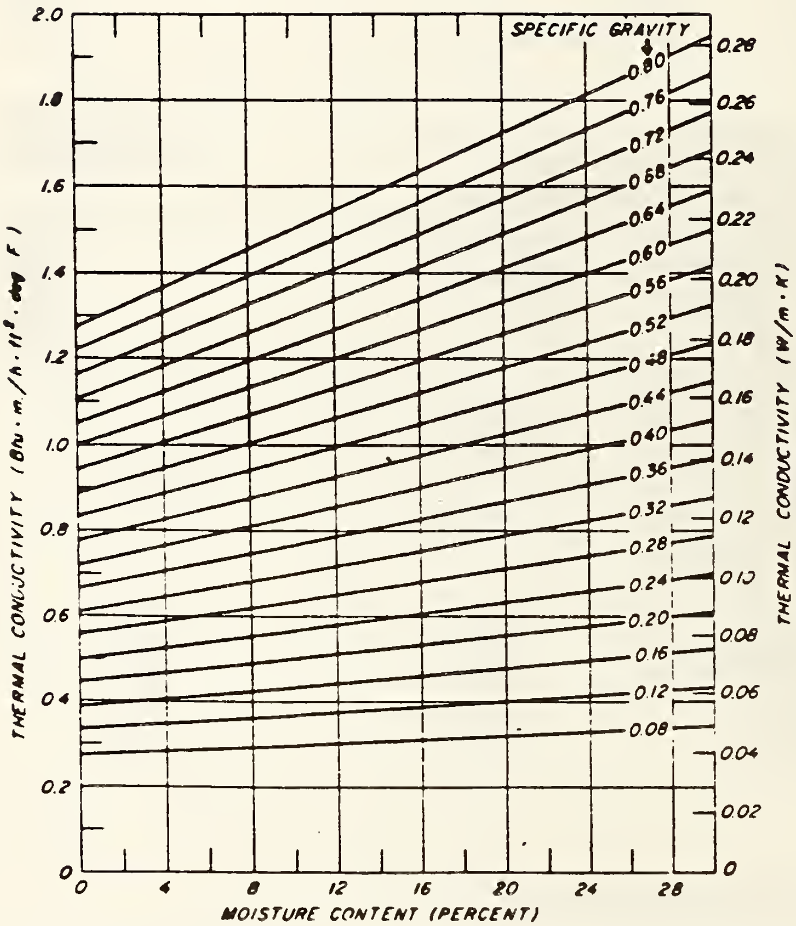
*The above thermal conductivity values of Kaowool modules are slightly lower due to a slight compression of the modules.

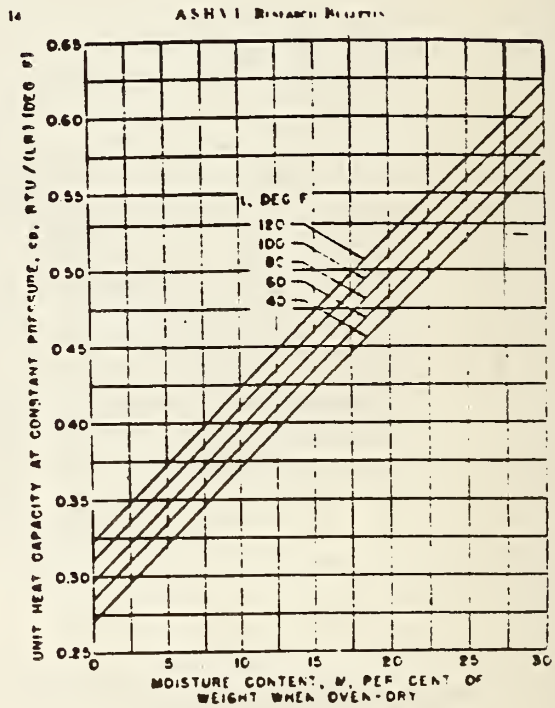
Ref. 21

Material: Wood; Plywood

Dry Density: Species:	400 kg/m^3 (25 pcf) Pine; Spruce; Hemlock; Redwood			510 kg/m^3 (32 pcf) Douglas Fir; Sugar Maple Maple			640 kg/m^3 (40 pcf) Oak; Birch; Silver Maple		
Moisture Content %	k W/m K	c J/kgK	kρc $\frac{J^2}{s\,m^4K^2}$	k W/m K	c J/kgK	kρc $\frac{J^2}{s\,m^4K^2}$	k W/m K	c J/kgK	kρc $\frac{J^2}{s\,m^4K^2}$
0	0.11	1210	53 x 10^3	0.13	1210	80 x 10^3	0.15	1210	120 x 10^3
10	0.12	1630	78	0.15	1630	120	0.18	1630	190
20	0.14	2050	115	0.17	2050	180	0.20	2050	260

c increases approx. 5% for each 10°C rise in temperature above 20°C.



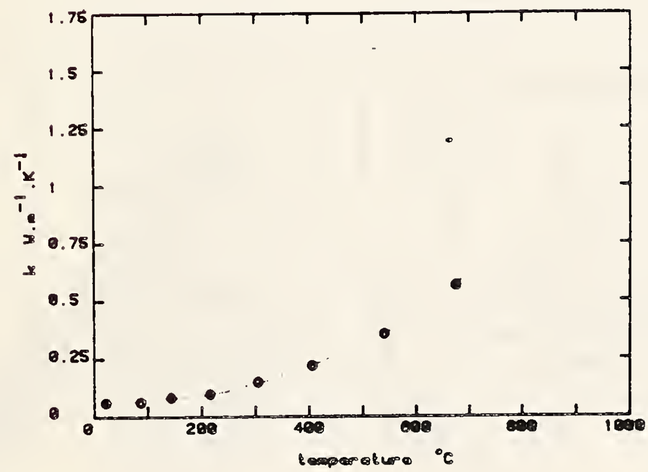


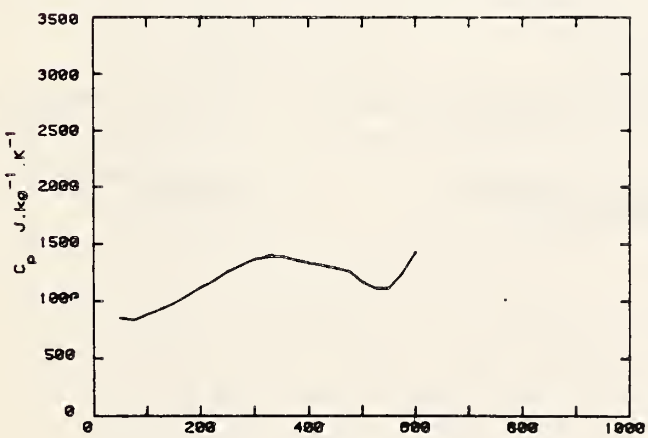
Ref. 23, 24

Material: Mineral Fiber (Thermafiber)

Density: 130 kg/m^3 (8 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/Kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.036	900	4.2 x 10^3
100	0.036	900	4.2
200	0.050	1200	7.8
500	0.30	1200	47
800	~ 0.9	~ 2000	~ 234





Ref. 17

Material: Steel

Density: 7850 kg/m^3 (490 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	62	480	234 x 10^6
100	59	500	232
200	53	520	216
500	40	660	207
800	~30	~1000	~236

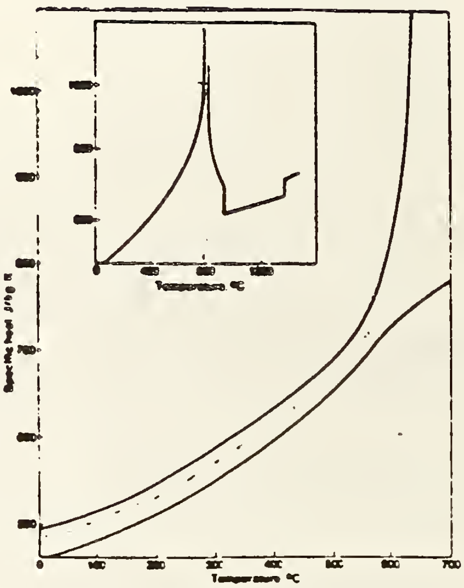


Figure 1 Effect of temperature on specific heat of structural steels [illegible] (10) (11) (12). [illegible] effect of transformation (13) (14)

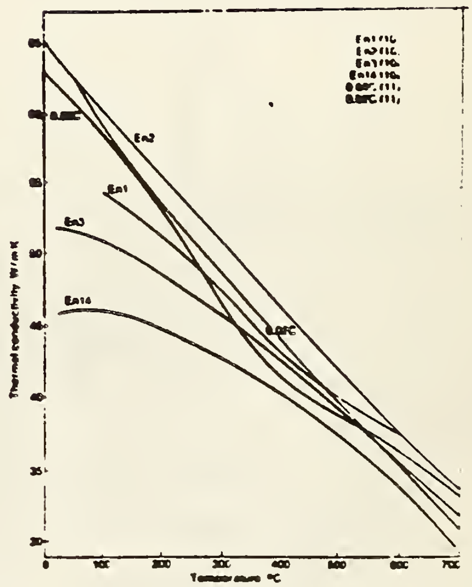


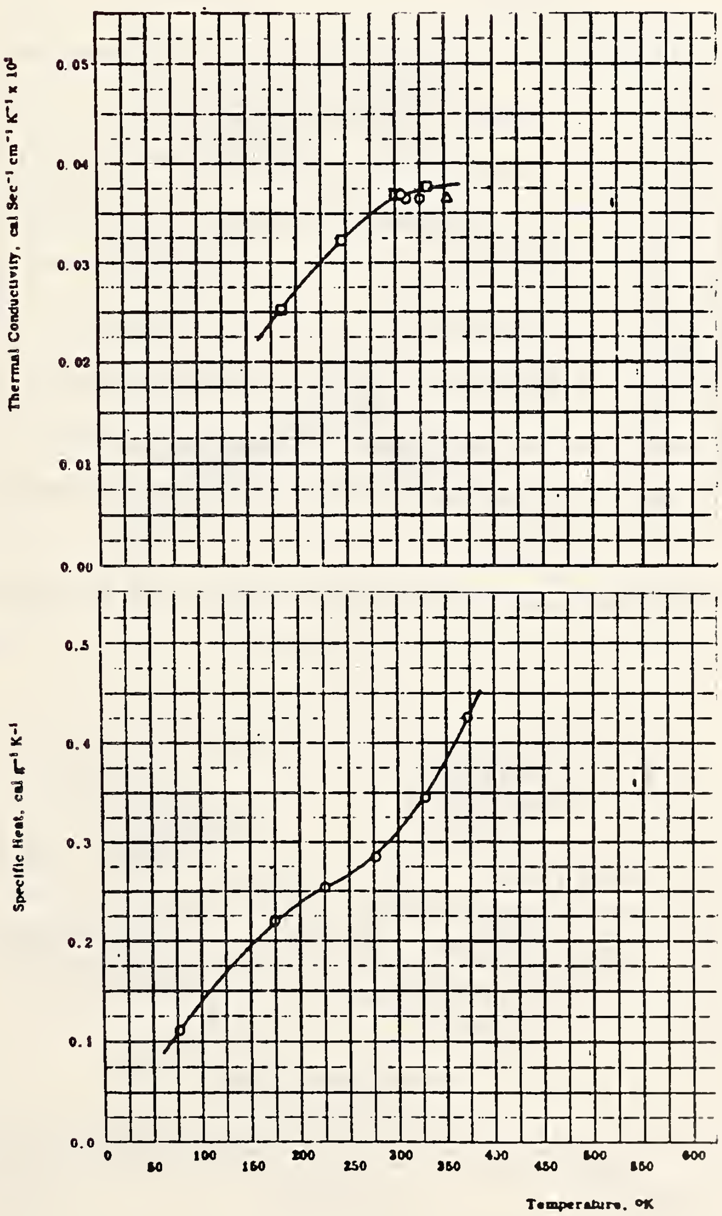
Figure 2 Thermal conductivity versus temperature for selected steels

Ref. 22

Material: Polymethyl methacrylate

Density: 1180 kg/m^3 (74 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{sm^4k^2}$
20	.15	1300	230×10^3
100	.16	1800	340×10^3

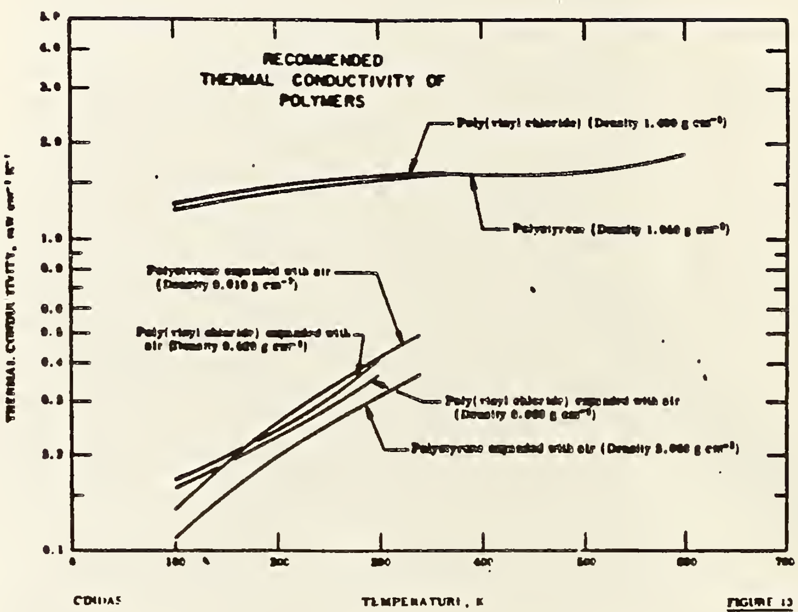


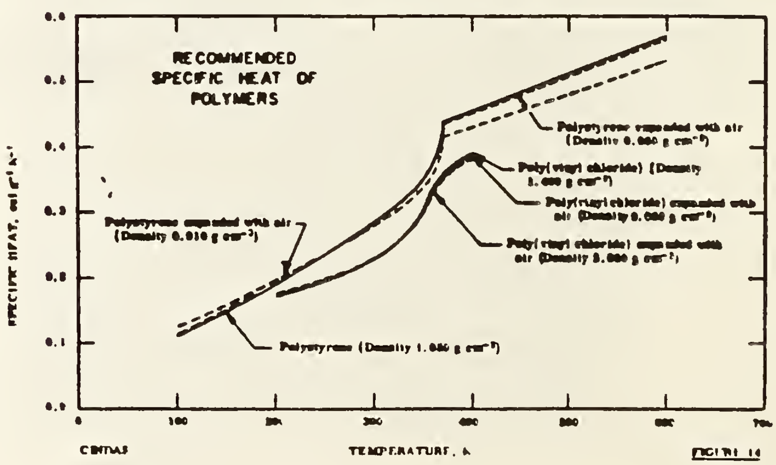
Ref. 25

Material: Polyvinyl Chloride

Density: 1400 kg/m^3 (87 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.16	950	210×10^3
100	0.16	1500	340





Ref. 26

Material: Polystyrene (solid)

Density: 1050 kg/m^3 (65 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.15	1160	180 x 10^3
100	0.16	1850	310
200	0.16	2080	350
300	0.18	2320	440

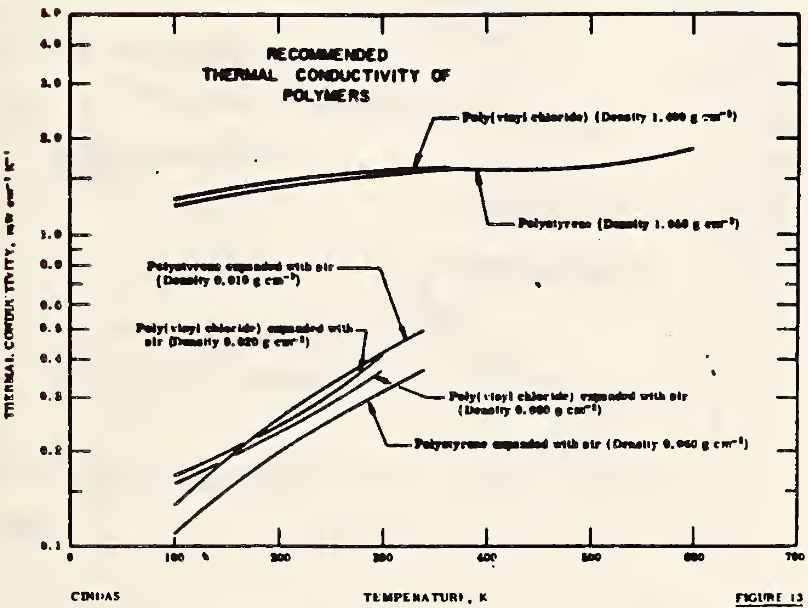


FIGURE 13

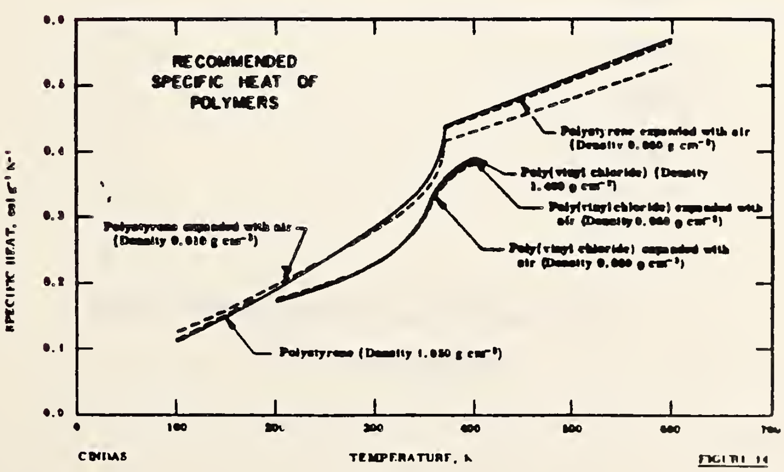


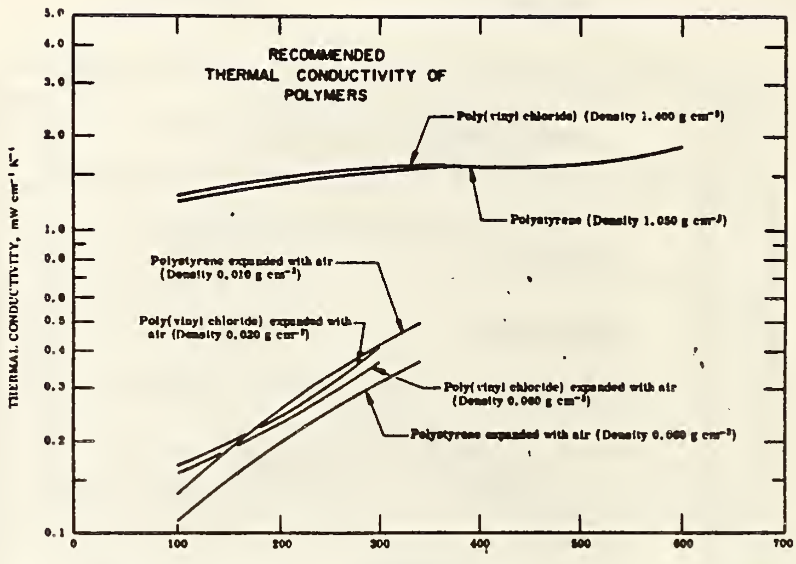
FIGURE 14

Ref. 26

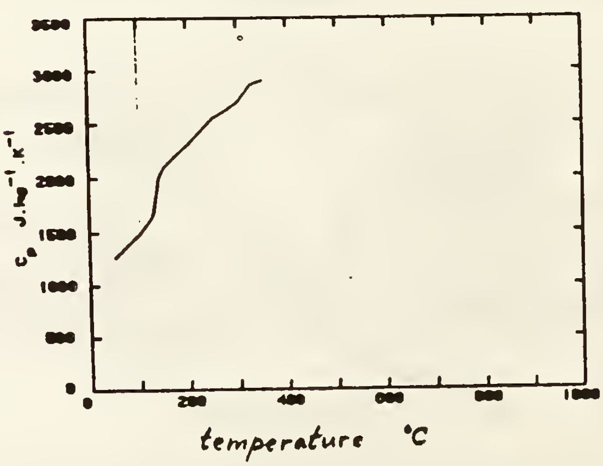
Material: Polystyrene Foam

Density: 34 kg/m^3 (2 pcf)

Temp. °C	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{s\ m^4 K^2}$
20	0.036	1150	1.4×10^3
100	~ 0.05	1500	~ 2.6×10^3



CINDAS FIGURE 13



Ref. 17, 26

Table 3. Thermal Properties of Assorted Materials (Room Temperature)

	Density ρ kg/m3	Thermal Conductivity k W/m K	Specific Heat c J/kg K	$k\rho c$ $\frac{J^2}{sm^4K^2}$
Air	1.3	0.024	1000	0.03×10^3
Insulation (rock or glass fiber)	50	0.040	800	1.6×10^3
Fiber insulation board (wood or cane)	240	0.05	1250	15×10^3
Vermiculite plaster	720	0.25	900	160×10^3
Gypsum plaster	1700	0.8	840	1140×10^3
Glass (soda-lime)	2500	1.2	750	2250×10^3
Urethane foam, rigid	24	0.023	1600	0.9×10^3
Urethane foam, flexible	50	0.040	1700	3.4×10^3
Hardboard	1000	0.20	1250	240×10^3
Carpet and pad	300	0.1	1400	42×10^3
Aluminum	2700	200	900	490000×10^3

Table 4. Total Normal Emissivity of Various Surfaces

Material	Temp.	ε_N
Asbestos board	20	0.96
Clay brick	20	0.93
	1000	0.5
Concrete	20	0.94
Glass	20	0.95
Gypsum	20	0.90
Aluminum	100	0.09
Aluminum, oxidized	500	0.3
Steel, rough, oxidized	20-400	0.95
Paint (all colors)	100	0.95
Wood (many species)	20	0.90

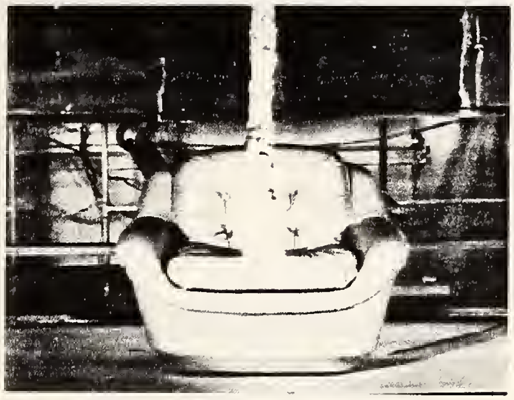
Table 5. Sources of Fire Response Data on Furnishings and Contents

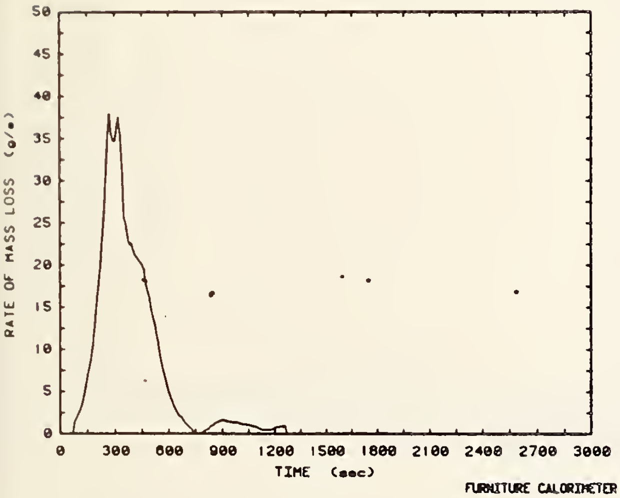
Product or Material	No.	Type of Burning O=Open C=Compt.	Mass Loss Tot.	Mass Loss Peak Rate	Mass Loss Graph	Heat Release Tot.	Heat Release Peak Rate	Heat Release Eff. H of C	Heat Release Graph	Smoke % Mass Conv.	Smoke O.D. Tot.	Smoke O.D. Peak	Smoke Ext. Coeff.	Smoke Graph	CO Peak	Gases CO_2 Peak	Gases O_2 Min.	Gases Graph	Targ. Irrad.	Ref.*
Upholstered chairs/easy chairs	5	O		X	X	X	X	X	X	X				X	X				X	5
Plain chairs	8	O		X	X	X	X	X	X	X				X	X				X	
Sofas	3	O		X	X	X	X	X	X	X				X	X				X	
Mattresses	2	O				X	X		X						X				X	
Bookcases	1	O					X													
Closets	9	O		X	X	X	X	X	X	X				X	X				X	
Upholstered chairs, sofas	13	O		X		X	X	X	X	X					X	X	X		X	6
Upholstered chairs	16	C	X	X	X			X					X	X	X	X	X	X	X	7
Wood cribs	10,4	C,O		X												X	X		X	8
Plastic cribs	10,4	C,O		X												X	X		X	
Wood cribs	5	C		X	X					X		X		X	X	X	X		X	9
Upholstered chairs	1	C		X	X					X		X		X	X	X	X		X	
Wastebasket (plastic)/contents	1	C		X						X		X		X			X		X	
Mattresses	10	C	X	X	X								X	X	X	X	X	X	X	10
Office furniture	19	O		X															X	11
Upholstered chairs	16	C		X	(typ)	calc.	calc.		calc			X		(typ)					X	12
Wood Cribs	3	C		X	(typ)	calc.	calc.		calc			X		(typ)					X	
Wastebasket/contents	22	C		X															X	13
Upholstered chairs	6	C		X																14
Sofas, couches	28	C		X																
Beds	6	C		X											X		X			
Television sets	3	C	X	X		X	X	X	X		X	X		X					X	15
Wastebasket (plastic)/contents	4	C				X	X		X		X	X		X					X	
Curtains	2	C	X			X	X	X	X		X	X		X					X	
Upholstered chairs	3	C	X		(typ)	X	X	X	X		X	X		X					X	
Christmas trees	3	C				X	X		X		X	X		X					X	
Upholstered chairs	28	C		X																16
Upholstered sofas	2	C		X																

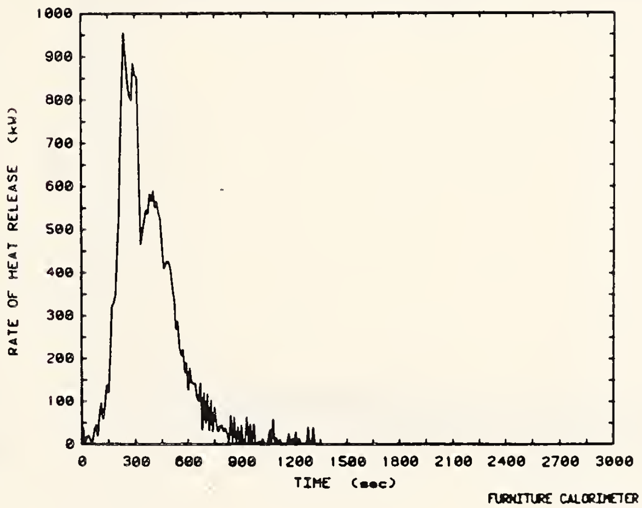
*See list of references for complete citation

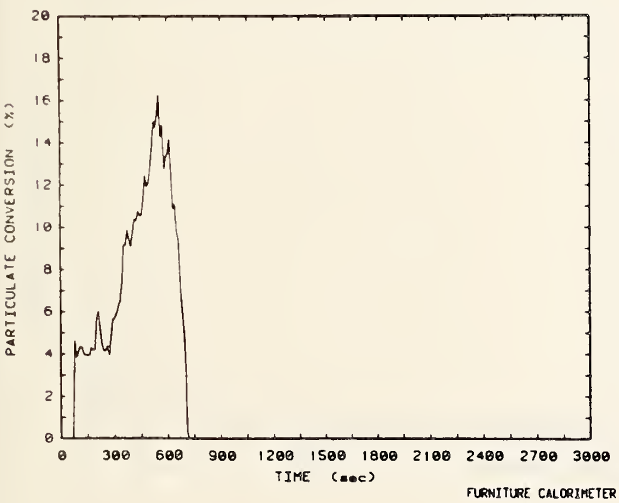
Table 6. Burning Rate Data for Selected Combustible Contents

Item: Upholstered Chair
Description: Molded PS frame;
Polyurethane foam padding;
PU/polyolefin fabric
Mass: 11.5 kg
Ref: NBSIR 83-2787 Test 48



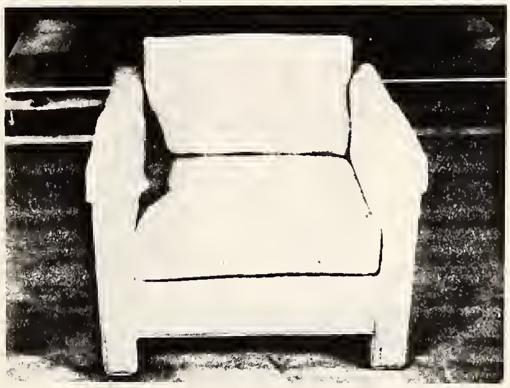


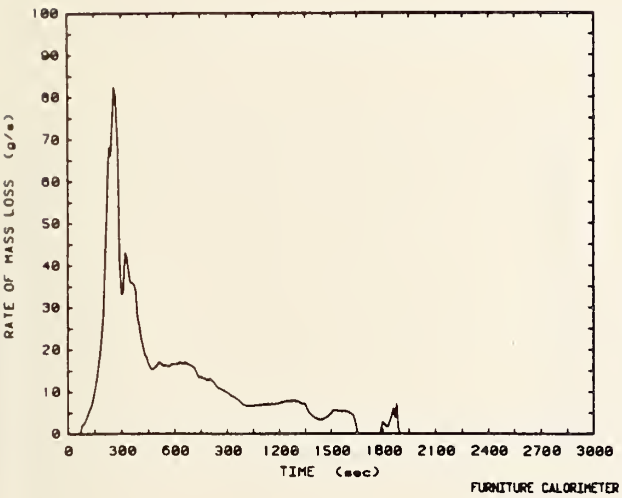


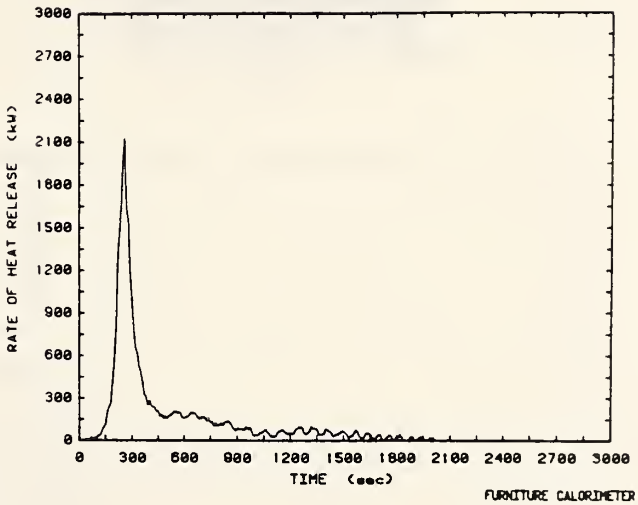


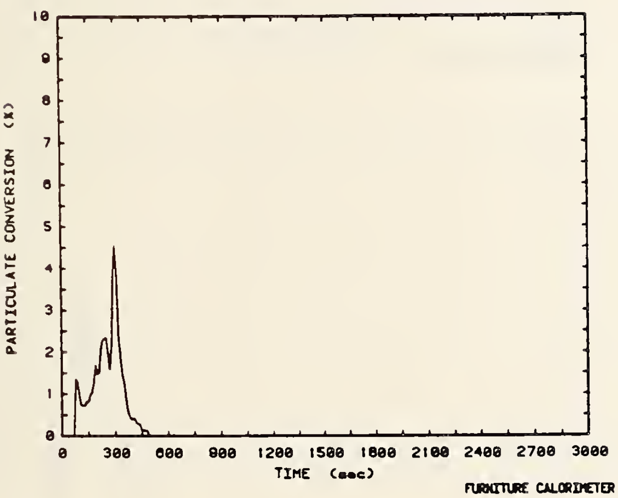
m_{max} g/s	q_{max} kW	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
38.0	960	33.3	16.2	774	3.1

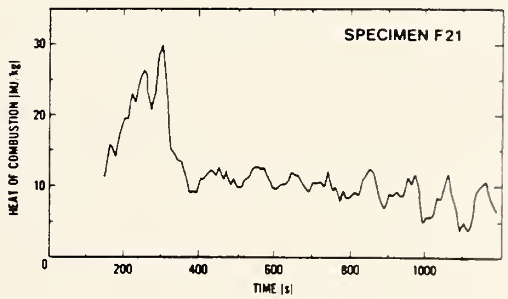
Item: Upholstered Chair
Description: Wood frame;
FR polyurethane foam padding;
polyolefin fabric
Mass: 28.3 kg
Ref: NBSIR 83-2787 Test 45





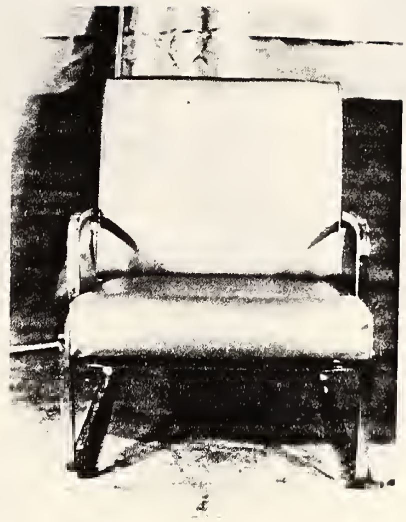


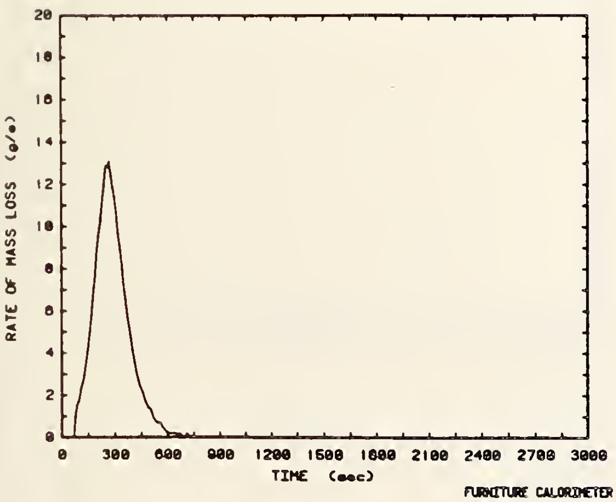


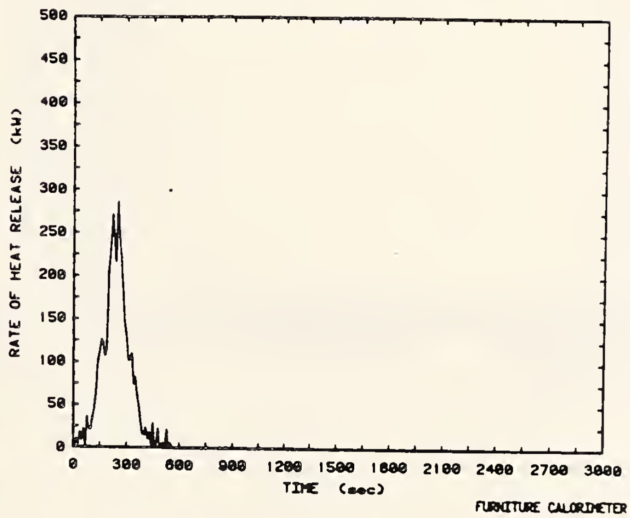


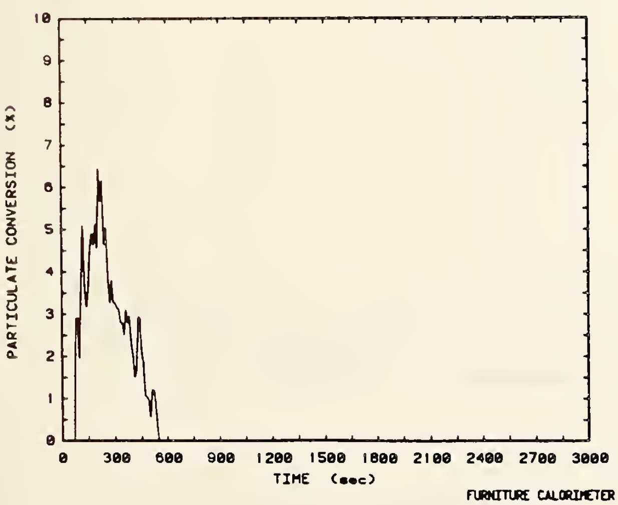
m max g/s	q max kW	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
82.5	2100	18.1	1.7	213	1.3

Item: Plain Chair
Description: Metal Frame;
Solid PU foam cushions;
Plastic fabric
Mass: 15.5 kg (1.9 kg combustible)
Ref: NBSIR 83-2787 Test 53



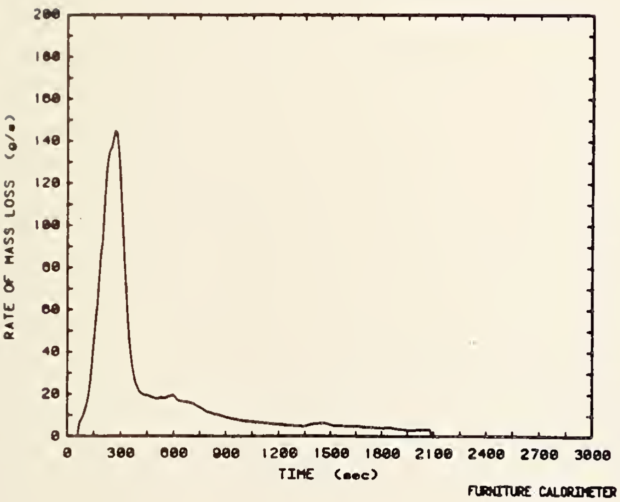


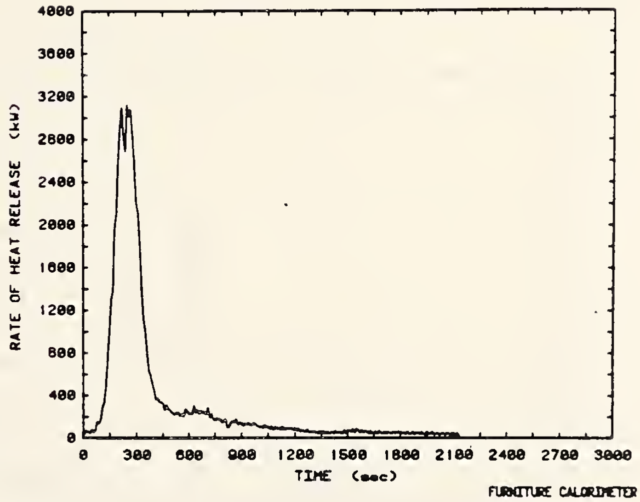


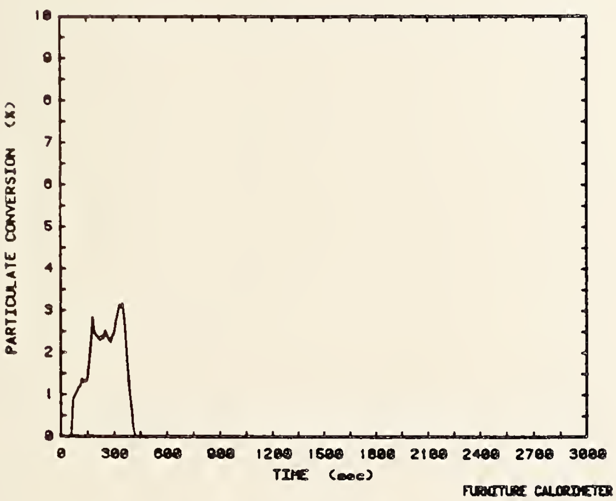


m max g/s	q max kW	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
13.1	290	21.4	6.5	101	1.1

Item: Upholstered sofa
Description: Wood frame;
FR polyurethane foam padding;
polyolefin cover fabric
Mass: 51.5 kg
Ref: NBSIR 83-2787 Test 38

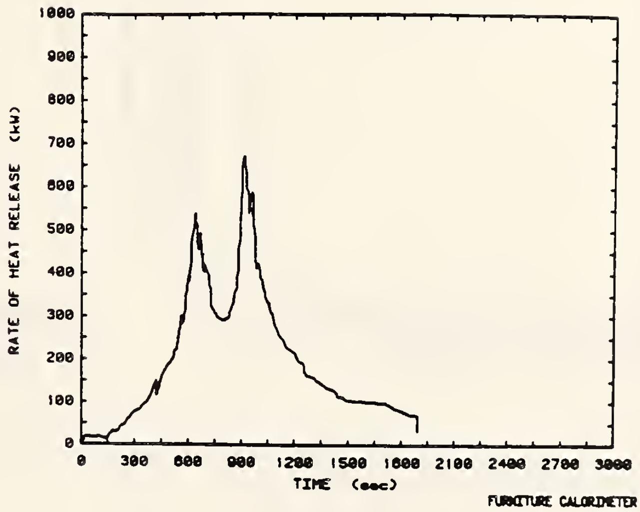






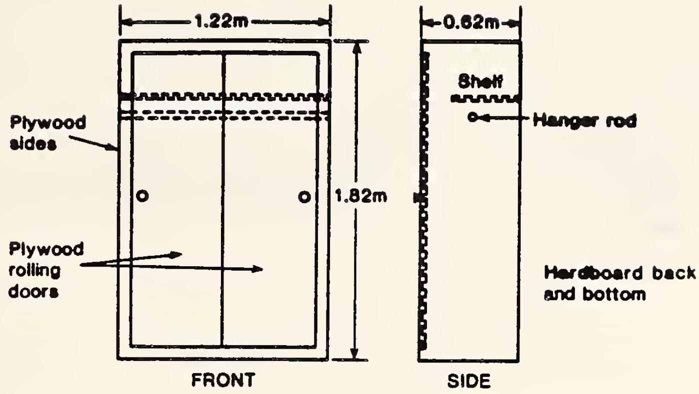
m max g/s	q max kW	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
145.3	3200	18.9	3.2	558	4.5

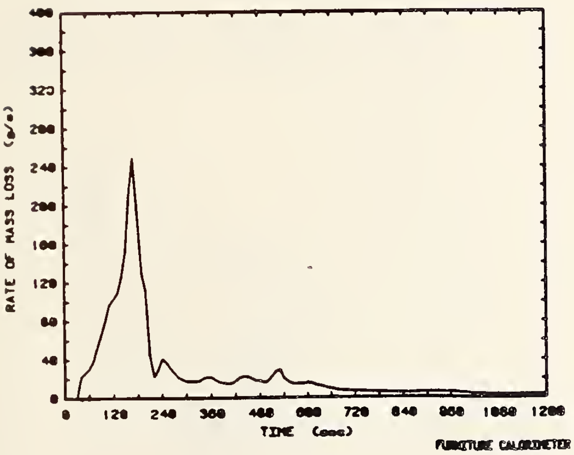
Item: Mattress/Boxspring
Description: Wood boxspring;
Mattress: 40% cotton felt;
40% PU foam; 20% sisal cover
Mass: 62.4 kg
Ref: NBSIR 83-2787 Test 67

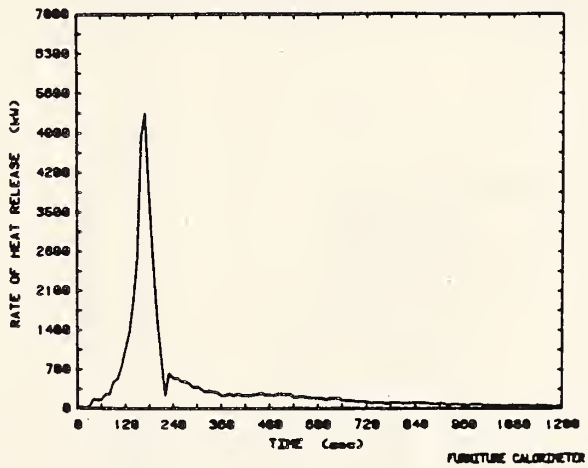


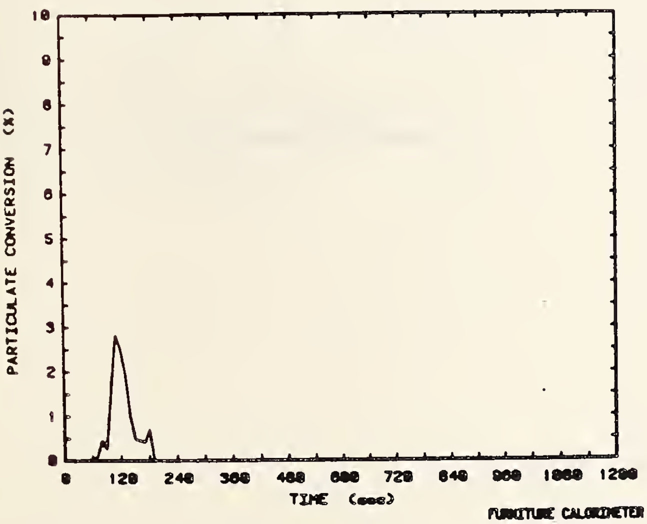
m_{max} g/s	q_{max} kW	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
	660				1.6

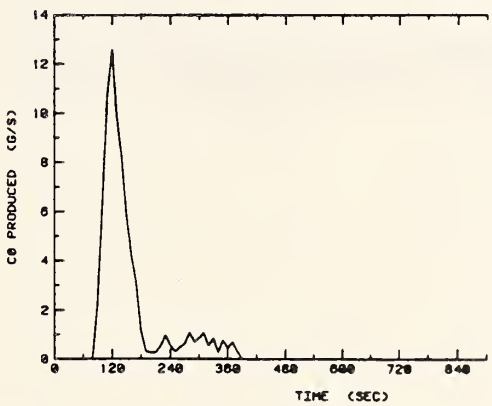
Item: Wardrobe Closet (commercial)
Description: Plywood with mahogany veneer; FR paint inside surfaces
Mass: 37.3 kg
Ref: NBSIR 83-2787 Test 42











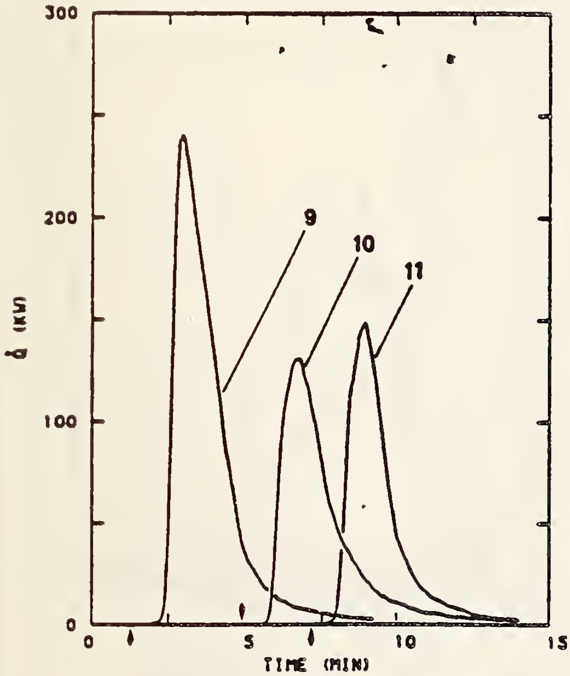
$\dot{m}$ max g/s	$\dot{q}$ max kW.	Avg. Heat of Combustion MJ/kg	Peak Smoke Particulate Conversion %	Total Smoke Product g	Peak Carbon Monoxide g/s
249.7	5300	15.9	2.8	146	12.6

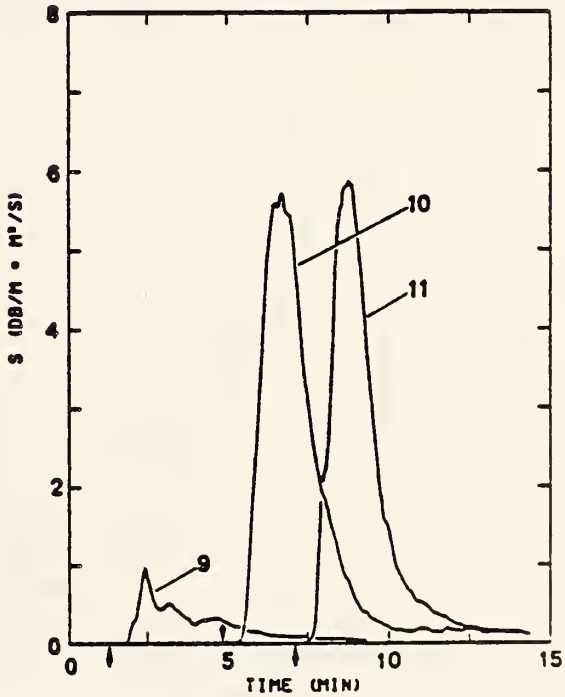
Item: Curtains

Description:

		Mass
9:	Cotton 0.31 kg/m^2	1.87 kg
10:	Cotton (39%); Polyester (16%); Acrylic (45%) 0.23 kg/m^2	1.43 kg
11:	Same "	1.43 kg

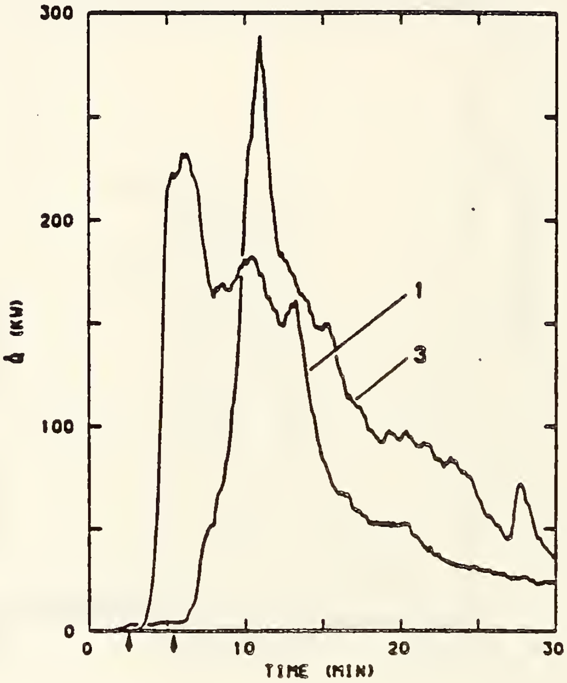
Ref: VTT Research Report 285

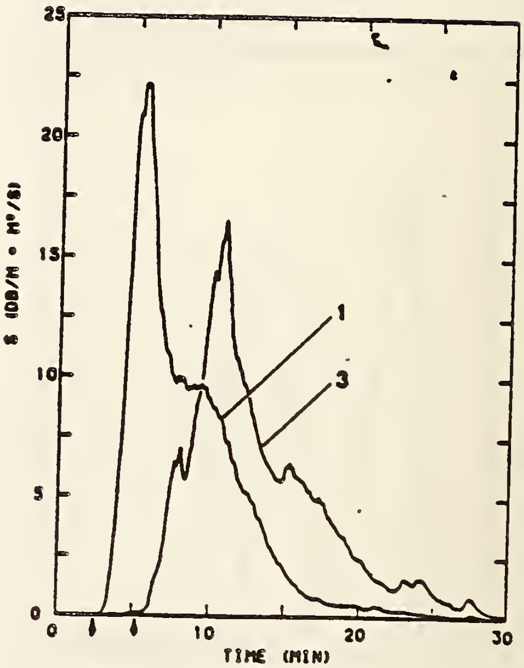




	Mass Loss kg	q_{max} KW	Total Smoke Produced $\frac{dB}{m}.m^3$	Effective Heat of Combustion mJ/kg
9:	1.7	240	100	14
10:	1.3	130	670	13
11:	1.3	150	590	12

Item: TV Set
Description:
1: 24" Black & White (1960s); wood cabinet — Mass: 32.7 kg
3: 26" Black & White (1960s); wood cabinet — Mass: 39.8 kg
Ref: VTT Research Report 285





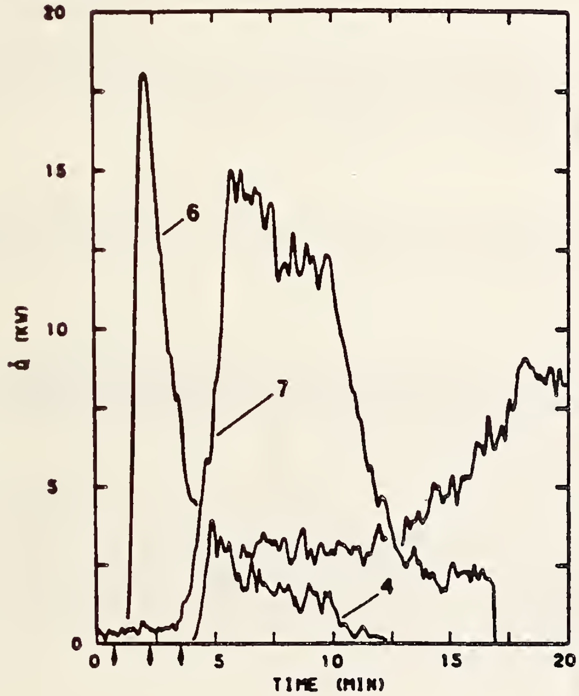
	Mass Loss kg	q_{max} KW	Total Smoke Produced $\frac{dB}{m} \cdot m^3$	Effective Heat of Combustion mJ/kg
1:	10.2	230	6700	14
3:	10.2	290	6300	15

Item: Wastepaper basket with contents

Description:

4:	Polyethylene basket	0.63 kg plus shredded paper 0.20 kg
6:	Polyethylene basket	0.53 kg plus shredded paper 0.20 kg
7:	Polyethylene basket	0.53 kg plus milk cartons 0.40 kg

Ref: VTT Research Report 285



	Mass Loss kg	q_{max} KW	Total Smoke Produced $\frac{dB}{m} \cdot m^3$
4:	-	4	6
6:	-	18	82
7:	-	15	46

Table 7 Thermochemical Data for Selected Organic Materials

Combustion Fuel	MW	Chemical Formula	Mass Fraction C	H	O	N	Heat of Combustion[a] MJ/kg Gross	Net	Heat of Formation[b] Kcal/mole	Stoichiometric Air-Fuel Mass Ratio[a]	Effective Heat of Gasification[c] MJ/Kg
Charcoal	12	C	1.000				32.8	32.8	0	11.47	
Methane	16	CH_4	.750	.250			55.5	50.0	-17.9	17.24	
Polyethylene	28	C_2H_4	.857	.143			46.4	43.3	-12.2	14.75	2.32
Polypropylene	42	C_3H_6	.857	.143			46.4	43.3	-19.3	14.75	2.03
Polystyrene	104	C_8H_8	.923	.077			41.5	39.8	8.3	13.24	1.70
Polytetrafluorethylene	100	C_2F_4	.240			.760(F)	5.0	5.0	-196.1	2.76	
Polyvinyl chloride	62.5	$C_2H_3C\ell$	.384	.048		.568(Cℓ)	17.1	16.4	-22.6	6.07	2.47
Polyoxymethylene	30	CH_2O	.400	.067	.533		16.9	15.6	-40.9	4.60	2.43
PMMA	100	$C_5H_8O_2$	.600	.080	.320		26.6	24.9	-105.8	8.27	1.63
Cellulose	162	$C_6H_{10}O_5$	.444	.062	.494		17.5	16.1	-230.3	5.10	3.55
Sucrose	342	$C_{12}H_{22}O_{11}$	.421	.064	.515		12.5	11.1	-857.5	4.83	
Polycarbonate	254	$C_{16}H_{14}O_3$	.756	.055	.189		31.0	29.8	-103.3	9.76	2.07
Acrylonitrile	53	C_3H_3N	.679	.057		.264	32.2	31.0	15.8	9.75	
Melamine (Formica)	162	$C_6H_6N_6$	.444	.037		.519	19.3	18.5	-20.0	6.38	
Nylon 6	113	$C_6H_{11}NO$	.637	.097	.142	.124	31.7	29.6	-83.2	9.96	
Polyurethane (rigid) GM-25	130.3	$C_{6.3}H_{7.1}NO_{2.1}$	.580	.055	.258	.107	23.9	22.7	-100.0	7.43	1.19
Polyurethane(flexible)	285	$C_{14.33}H_{24.94}O_{4.63}N$	.602	.088	.260	.049	26.6	24.6	-393.6	9.79	1.23

a. Ref 27
b. Ref 28
c. Ref 29

NBS-114A (REV. 2-80)

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5. AUTHOR(S)

Daniel Gross

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

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8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

[ ] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

Sources of data needed for predictive modeling of fire growth by FAST and ASET, two computer codes developed at the Center for Fire Research, are identified for a few selected materials. Data includes thermophysical properties of compartment lining materials and burning rates and combustion product generation rates for typical combustible contents.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

ASET; Burning rate; Combustion products; FAST; Fire models; Fire properties; Heat release; Smoke generation; Thermal inertia; Thermal properties

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